CHLORIDE IN SHALLOW COASTAL WELLS IN KANYAKUMARI DISTRICT

By

P. CHARLES D. MONY.

DEPARTMENT OF CIVIL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

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A Thesis Submitted
in Partial Fulfilment of the Requirements
for the Degree of

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By

P. CHARLES D. MONY.

to the

DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

JANUARY, 1986

To

My Parents & Brother

CERTIFICATE

This is to certify that the present work entitled "CHLORIDE IN SHALLOW COASTAL WELLS IN KANYAKUMARI DISTRICT" has been carried out by Mr. P. CHARLES D. MONY under my supervision and the same has not been submitted elsewhere for a degree.

BIKASH C. RAYMAHASHAY
Professor
Department of Civil Engineering
Indian Institute of Technology
Kanpur

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- P. CHARLES

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ABSTRACT

This thesis summarizes the salinity features of eight open wells situated in the coastal region of Kanya Kumari District. The wells are too shallow to reach the fresh water - sea water interface underground. The chloride concentration ranges from 18 to 503 mg/l. The regional variation of Cl^- has been represented in isochlor maps and sections.

The relatively low chloride values indicate that there is considerable mixing of sea water with fresh ground water at shallow depths. There are two main sources of Cl namely (1) infiltration from stream channels which carry sea water during tides and (2) dissolution of salt pans. Presence of sandy soil helps the seepage of salt water from streams. Wells near towns and villages may derive Cl from domestic sewage. Wells located near cultivated lands in clayey soil show depression of low - Cl water to relatively large depths.

These features, typical of a populated coastal tract, indicate that local factors influence chloride variation in shallow open wells to a greater extent than a regional sea water intrusion.

CHAPTER- 1

INTRODUCTION AND OBJECTIVES

Chloride is one of the important components in ground water. Chloride occurs in all natural waters in widely varying concentration. Upland and mountain supplies usually are quite low in chloride, whereas river and ground water usually have a considerable amount. Sea water represents very high chloride levels.

Chloride in sea water is mainly derived from mid oceanic ridges (Juvenile water) and volcanoes. The ocean spray in coastal areas is carried inland as droplets or as minute salt crystals which form when the droplets evaporate. This source constantly replinishes the chloride in coastal waters. Surface and subsurface waters also dissolve chloride from topsoil and deeper formations and ultimately join the ocean. This is known as the chloride cycle.

Another important source of chloride in ground water near populated areas is domestic sewage. Many agricultural and industrial effluents also contain high chloride. Chlorination of water supplies may also contribute chloride in receiving waters.

Chloride in reasonable concentration is not harmful to humans. At concentration above 250 mg/l, it gives a salty taste

to water, which is objectionable to many people. For this reason, the U.S. Public Health Service recommends that chloride be limited to 250 mg/l in supplies intended for public use (Sawyer, 1960). However, waters having chloride concentration only upto 20 ppm were considered to represent uncontaminated ground water by Carr (1969), whereas chloride concentration greater than 40 ppm was considered to indicate contamination by sea water.

The chloride determination is used to control pumping of ground water from locations where intrusion of sea water is a problem. Chloride is used as a tracer to find out the extent of salt water intrusion in coastal aquifers.

For the present study, an area in the coastal tract of Kanya Kumari District (Fig. 1.1) was selected to identify the parameters which possibly influence the variation of chloride in well water. A review of previous work indicated that there are physical parameters like density of water, depth of well, permeability of aquifer etc. Similarly there are chemical parameters like total dissolved solids (TDS), sodium content, ion exchange with aquifer materials etc. With this background, it was decided to monitor 8 wells along the coast over the seasonal cycle before and after monsoon. Complete chemical analysis of water was avoided, and only parameters relevant to variation of chloride were determined. Thus, the main objectives

Fig. 1·1 Location of study area

of this work can be listed as (1) To establish the surface geology and soil type of this area. (2) To collect samples of well cuttings wherever available to establish the mineralogy of subsurface formation. (3) To determine the grain size distribution in near surface formations, and thereby to infer the permeability characteristics. (4) To determine simple parameters like conductivity, TDS, sodium concentration and correlate them with chloride concentration. (5) To correlate the depth of water table with chloride content and ground topography.

CHAPTER- 2

LOCAL GEOLOGY AND PREVIOUS WORK

2.1 Local Geology :

The study area is situated to the west of Kanya Kumari (Cape Comorin). This forms a part of the old Travancore State. According to the Pascoe Manual (1965), the state of Travancore is divided into 4 belts oriented in a North-South direction. The Western most coastal belt consists of recent deposits. It is followed towards the East by sedimentary rocks of Pleistocene or Late Tertiary age. Then occurs the third belt of laterite capped crystalline rocks and finally unweathered crystalline rocks (Charnockites and Peninsular gneiss) forming the Sothern Ghats.

The wells studied during the present investigation are located in the coastal belt (Fig. 2.1). According to a personal communication from Tamil Nadu Water and Drainage Board, a typical lithology near Manavalakurichi (Well No. 1) is as follows :

Coastal Sands	-	Recent
Red Teri Sands	-	Sub recent
Clays and Sandstone (Warkalli formation)	-	Tertiary
Charnockites	-	Archaean.

The coastal sands contain heavy minerals like ilmenite, garnet, monazite and zircon. The clay content is small, but

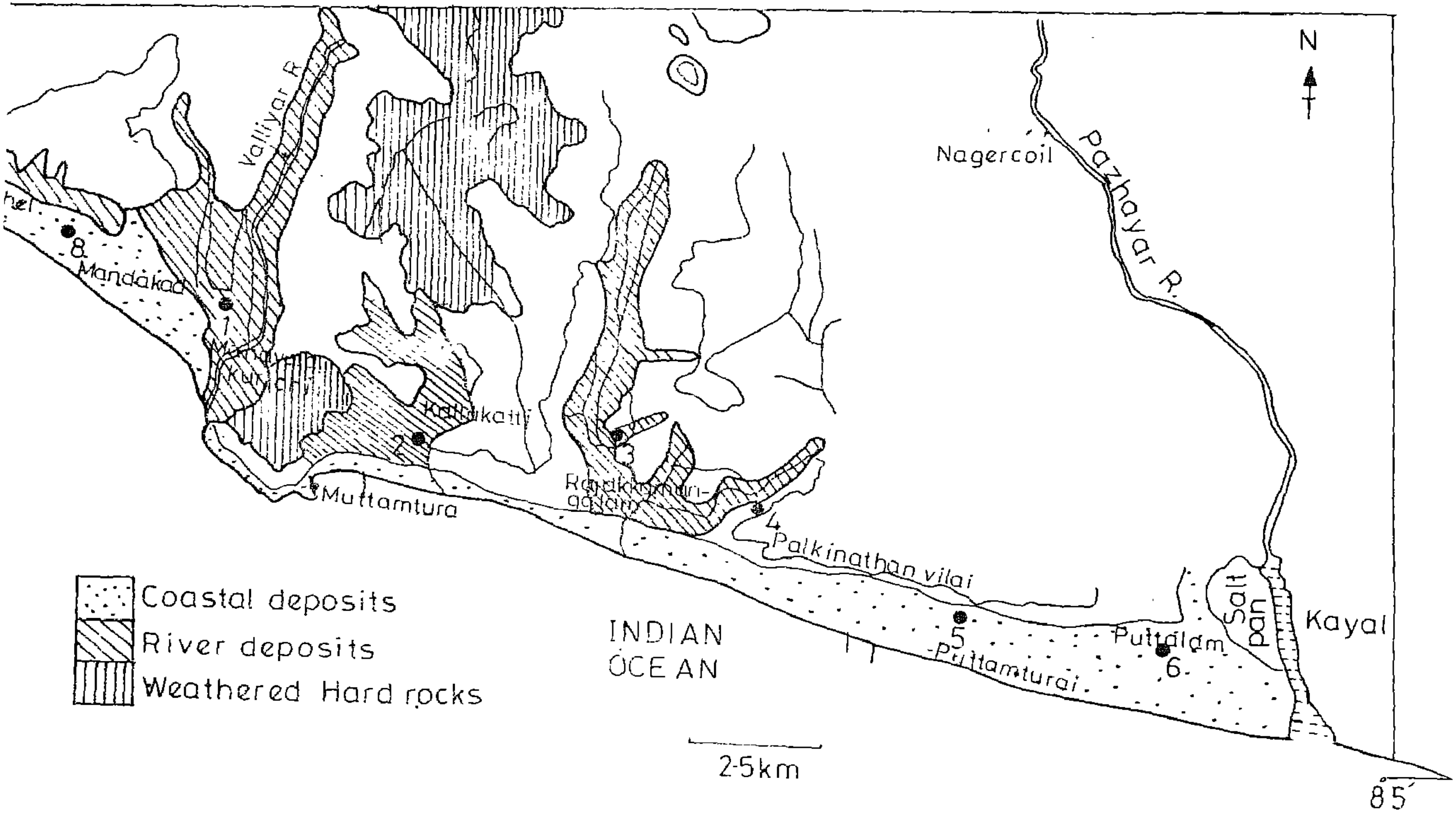


Fig.2·1 Geological map of Kanyakumari coast

it is reported to increase from West to East. Red Teri sand is locally clayey and has been found to have limited infiltration of ground water. Sedimentary rocks equivalent to Warkalli are seen in the area North of Colachel-Manavalakurichi road (Well no. 8, 7 and 1). Hard rocks belonging to the Charnockite suite are observed near Colachel (Well No. 7) and near Muttamtura (between Well No. 1 and 2).

The main soil type of this area is lateritic which occurs over weathered sandstone and Charnockite. The top soil near Kanankurichy (near Well No. 2) is a mixture of Black Cotton Soil and laterite. It is reported to extend to a depth of about 10 feet (3 meters).

Problems of sea water intrusion have been reported at several locations in this coastal area. It is believed that saline water is recharged into the aquifers through Kayals and small estuaries, which are flooded by sea water during high tide. Another source of salinity of well water is the local occurrence of saltpans.

2.2 Previous Work on Coastal Ground Water :

Coastal aquifers come in contact with the ocean at or seaward of the coast line. Under natural conditions, fresh ground water is discharged into the ocean. With increased demands for ground water in many coastal areas, however, the seaward flow of ground water has been decreased or even reversed

causing seawater to enter and to penetrate inland in aquifers. This phenomenon is seawater intrusion.

The problem of seawater intrusion has increased as population centers and concomitant water demands in localized coastal areas have developed. One of the earliest reports of intrusion was published in 1855 by Braithwaite, who described the increasing salinity of water pumped from wells in London and Liverpool, England. The problem of seawater intrusion in ground water is one which has received frequent mention in the literature for the past 100 years (Todd, 1959).

Parker (1951) stated that canals near the coast have induced encroachment of salt water in two ways, (1) They have served to drain off fresh water stored in the aquifer, (2) They have acted during certain dry seasons as inland extension of sea carrying salty water inland for several miles and allowing it to leak into and contaminate the aquifer all along their course.

Wilmoth (1972) noted that salty ground water is commonly encountered at relatively shallow depths beneath the major stream channels in the Western half of West Virginia.

Wait and Callahan (1965) proposed the following mechanisms for occurrence of saltwater in coastal areas, (1) Vertical contamination by ocean tides and storm winds. (2) Lateral encroachment of salt water in water table and artesian aquifers caused by the reduction of fresh water head due to pumping,

(3) Lateral encroachment by the inland movement of ocean water in canals and drainage channels.

Harris and Wilder (1964) correlated the field permeability of sediments with chloride content of ground water. Zones of low permeability were correlated with zones of high chloride.

Visher and Mink (1964) and Carr (1969) observed the relationship that the total disssolved solids and specific conductance of ground water varied linearly with chloride content.

Schmorak (1969) noted that the increase of salinity is due to heavy pumping. As a well begins to pump, a local rise (upcoring) of the interface occurs below the well. At low pumping rates, a new equilibrium may be established with an upconed interface but with practically no saline water being pumped. At higher pumping rates, the upconing interface may reach the well and contaminate the pumped water.

Kishi and Yoshiaki (1977) as well as Kafri and Arad (1979) observed that heavy consumption of ground water has sometimes brought about undesirable phenomena such as lowering of water levels, subsidence of land surface and intrusion of seawater into coastal aquifers.

The phenomenon of seawater intrusion into ground water is frequently seen in coastal regions, not only near large cities but also near small towns. Shukla (1984) pointed out

that the saline water intrusion in Saurastra region of Gujarat is due to intensive pumping.

Chauhan et al. (1984) and Fawzia (1984) cited low chloride content of ground water at shallow depths and high chloride content at greater depths.

CHAPTER-3

METHOD OF WORK

3.1 Field work :

Eight wells were located along the coast from Colachel to Puthalam area of Kanya Kumari District of Tamil Nadu. The locations of the wells have been shown in Fig. 3.1.

Water samples were collected from these wells in the pre-monsoon (June 1985) and post-monsoon (September 1985) periods. Depth to water from ground surface was measured in both periods. Cutting samples were collected from well No. 2, 3 and 4. Some details about the wells are given in Table 3.1.

Table 3.1 - Description of wells

Well No.	Location	Remarks
1	Manavalakurichi	Situated near a small village
2	Kallukatti	Cutting sample was collected, sandy soil, situated near a channel.
3	Pillavilai	Sandy clay in cutting sample.
4	East Palkinathan Vilai	Situated in a cultivated area Cutting sample clayey in nature.
5	Mela Krishnan puthoor	Located near a small village.
6	Puthalam	Situated near a salt pan and kayal.
7	Colachel	Situated in a town, salt pan is located nearby.
8	Mandaikadu	Situated near a small village

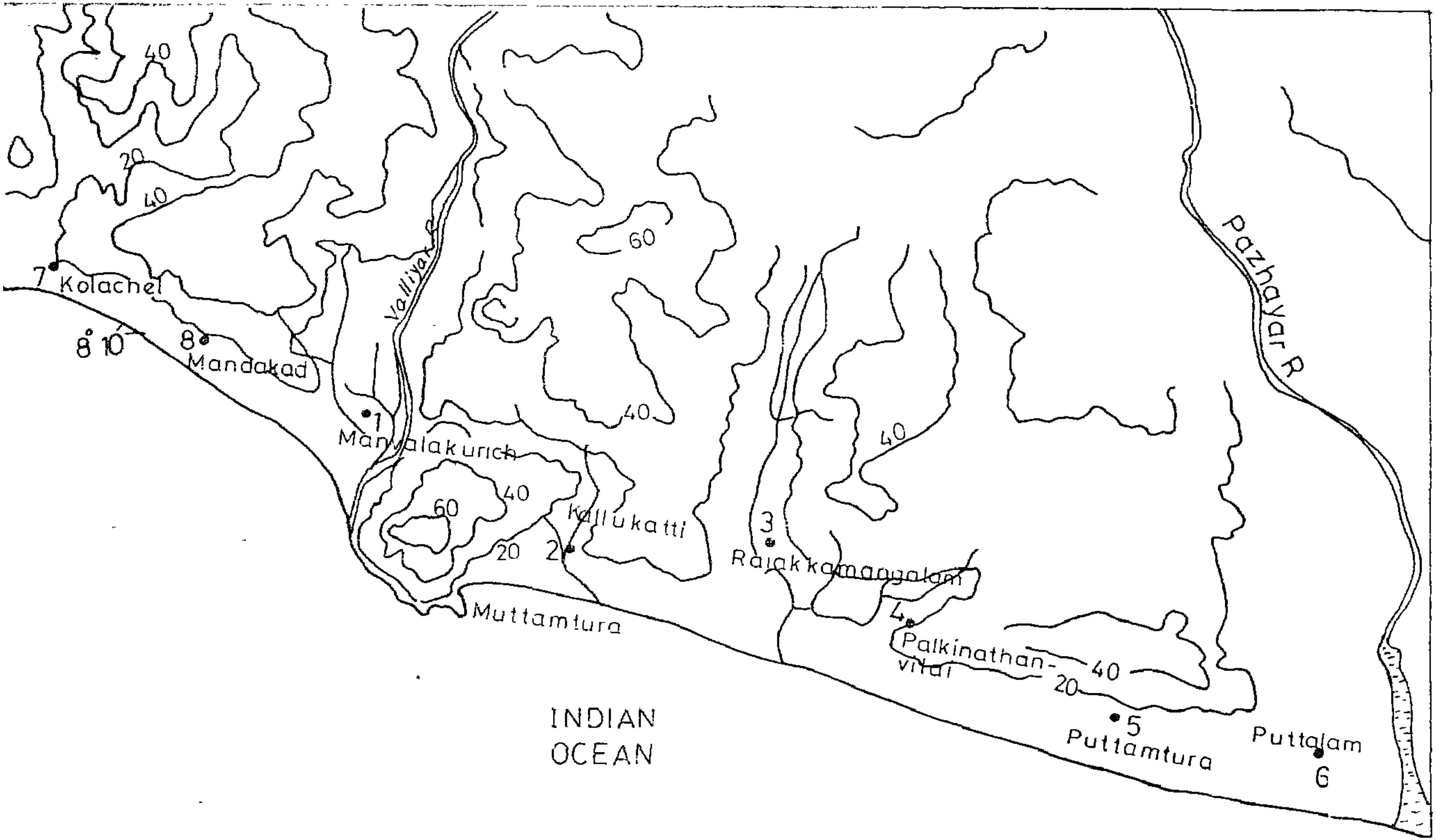


Fig.3·1 Location of wells

3.2 Laboratory Work :

The cutting samples were processed for X-ray diffraction analysis. To enhance the clay peaks, some samples were studied in the form of a sedimented slide. The samples were scanned by GEC-5, 30 KV X-ray using Cu K radiation and Ni-filter with cps varying from 500 to 1000 (1K).

The clay fraction of the cutting samples was determined by the standard hydrometer test. The complete grain size distribution for the sample from well No. 2 was determined by Sieve Analysis and Hydrometer Test.

The following parameters were measured for the water samples (1) pH (2) Conductivity, (3) TDS by evaporation, (4) Sodium and (5) Chloride samples were diluted wherever necessary. pH was estimated by BDH indicator papers. Conductivity was measured using conductivity cell and Systronics digital conductivity meter. T.D.S. was calculated from conductivity values using a empirical relationship, which assumes a linear distribution of TDS against conductivity with an average slope of 0.65. Therefore, TDS (mg/l) = 0.65 x Conductivity (μ m hos/cm) at 25°C. For those samples which showed relatively high T.D.S. by this method, the presence of non-ionic species may introduce an under estimation. Therefore, TDS was redetermined by the evaporation method.

Sodium concentration was measured by a Systronics MK-1

flame photometer attached to a moving spot galvanometer. The instrument was caliberated with standard NaCl solution giving full scale deflection for 25 mg/l.

Chloride was determined by titrimetric method using 0.014N silver nitrate as titrant and potassium chromate as an indicator.

$$Cl^- \ (mg/l) = \frac{ml\ AgNO_3 \times 35.46 \times 0.014 \times 1000}{ml\ of\ sample}$$

CHAPTER-4

RESULT AND DISCUSSION

A survey of previous literature on water quality in coastal aquifers (chapter-2) indicates that chloride, which is believed to be an indicator of mixing between sea water and fresh water, does not show any systematic variation. There are many examples of interstratification of fresh and salt water in coastal wells. Although the Ghyben-Herzberg relationship explains the general nature of intrusion of seawater into coastal aquifers, in those cases where deep wells have reached the seawater interface, the depths are different from the theoretical values. Several other local factors have been suggested from time to time to explain chloride concentration in coastal aquifers, for example aquifer properties, pumping characteristics and land forms. In the present study, an attempt was made to identify a few relatively simple parameters which might have some influence on the chloride content in shallow open wells along the Kanyakumari coast. The main results are summarized below.

4.1 Mineralogy of well cuttings :

It was possible to collect the material dug out from 3 wells and dumped at the surface. The sample from Well No. 2 showed strong X-ray peaks of quartz with smaller peaks of

feldspar, kaolinite, mica and calcite (Fig. 4.1). A slide prepared by eliminating the quartz fraction, showed a peak at 14.96 Å which was confirmed to be due to montmorillonite by glycolation. (Fig. 4.2).

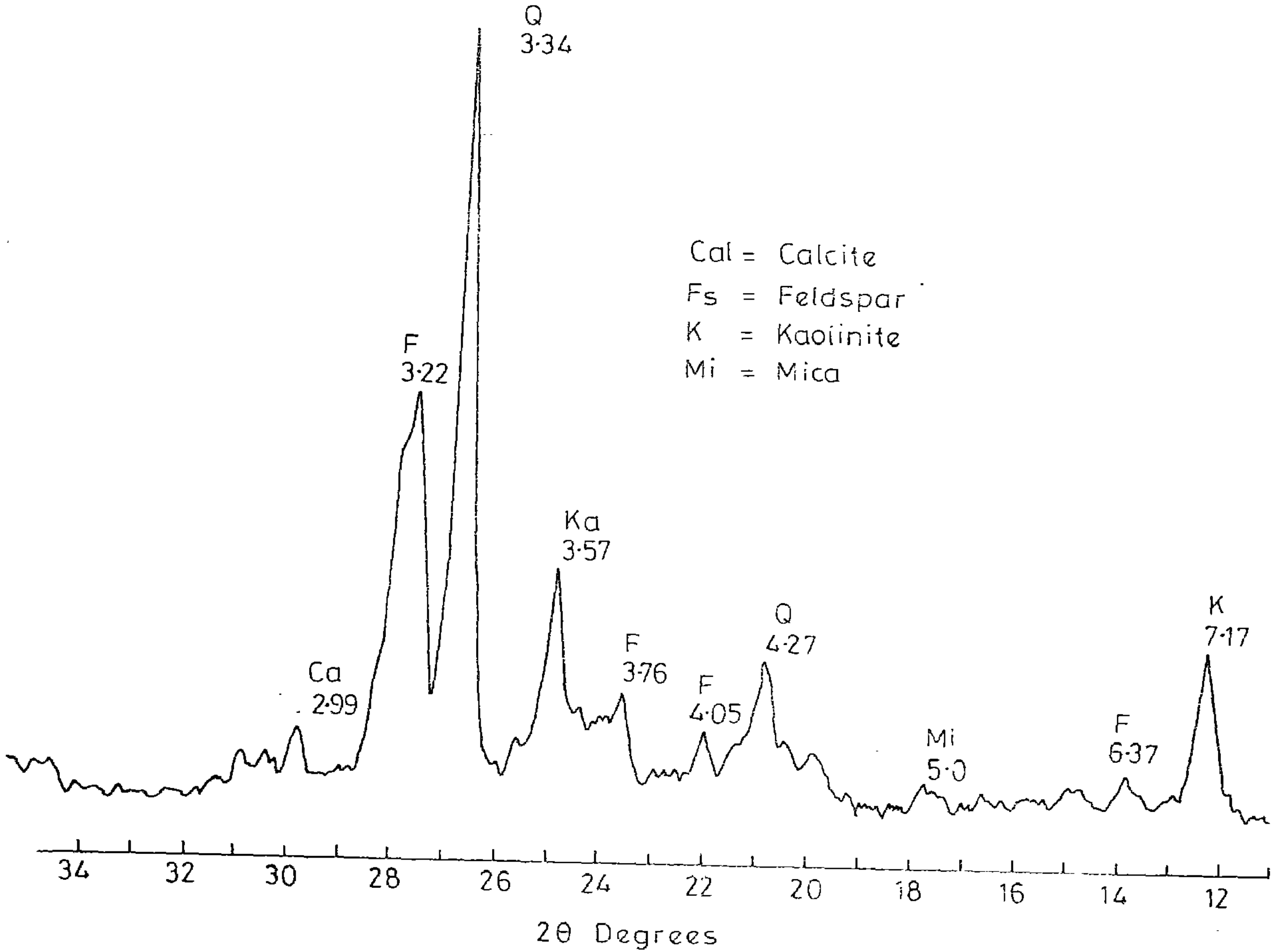
The sample from Well No. 3 showed strong X-ray peaks of quartz with minor peaks of kaolinite, feldspar and mica (Fig. 4.3). The material from Well No. 4, on the other hand showed strong X-ray peaks of kaolinite with minor quartz (Fig. 4.4).

4.2 Grain Size Analysis :

The same 3 samples of well cuttings were subjected to standard grain size analysis procedure (Fig. 4.5). The results recorded in Table No. 4.1 show that the material in Well No. 2 is distinctly sandy, with 4% gravel size, and 84% sand size. The sample from Well No. 3 is also sandy. However, the clay fraction is 23% as compared to 4% in Well No. 2. The material from well No. 4 is obviously different, having a clay content of 73%. X-ray analysis indicated that this sample is dominated by kaolinite. It is expected that the hydraulic conductivity (permeability) will be higher in Well No. 2 and 3 compared to Well No. 4.

Table No. 4.1 : Mineralogy and Grain size percentage of well cuttings.

Well No.	Mineralogy	Grain size Analysis Sand %	Silt%	Clay %
2	Quartz, feldspar, kaolinite, montmorillonite, mica & calcite	84 4% gravel	8	4
3	Quartz, kaolinite, feldspar, & mica	70	7	23
4	Kaolinite & Quartz	10	17	73



X-RAY DIFFRACTION PATTERN OF CUTTING SAMPLE NO.

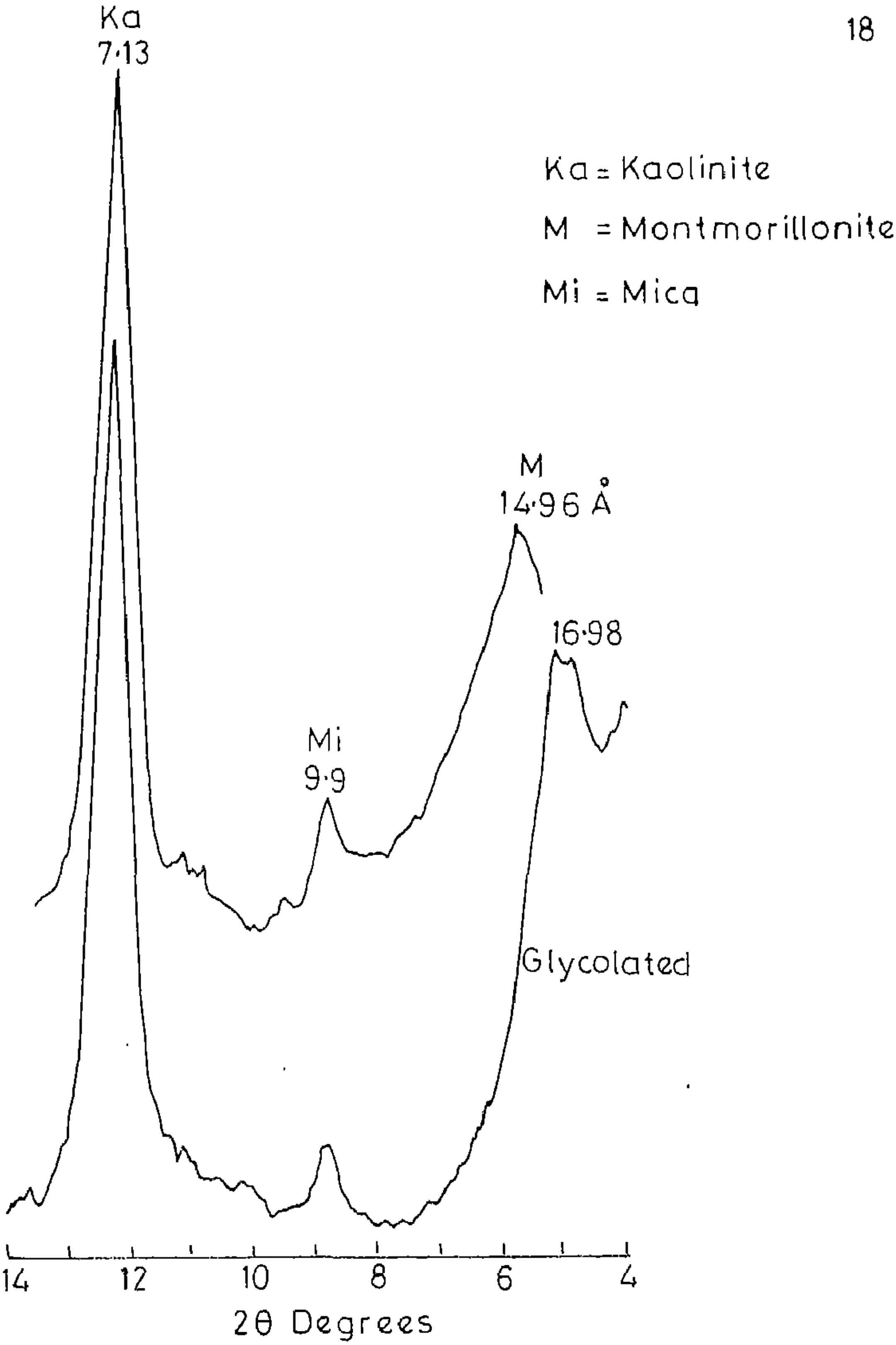


FIG.4·2 X-RAY DIFFRACTION PATTERNS OF CUTTING SAMPLE NO. 2 (SLIDE)

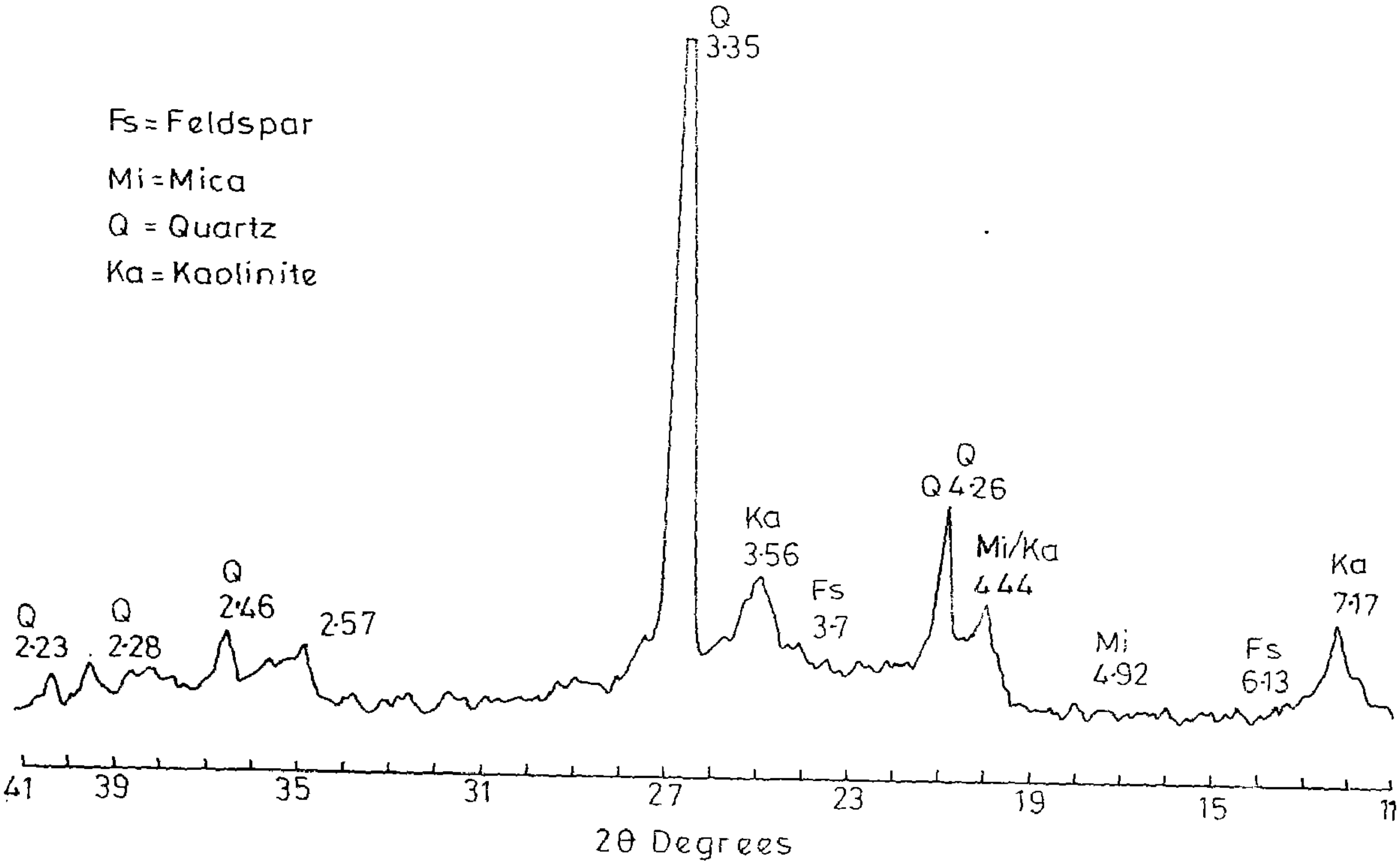


FIG. 4·3 X-RAY DIFFRACTION PATTERN OF CUTTING SAMPLE NO. 3

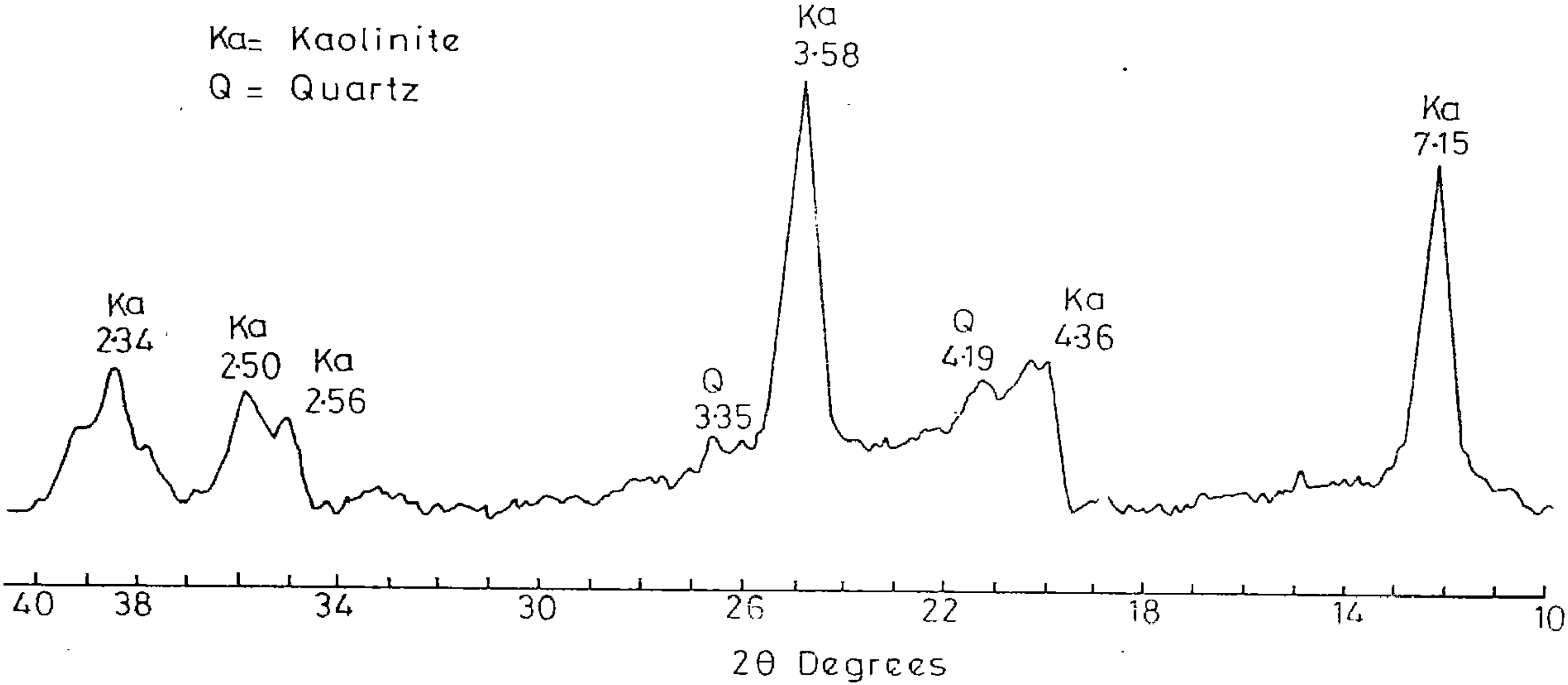
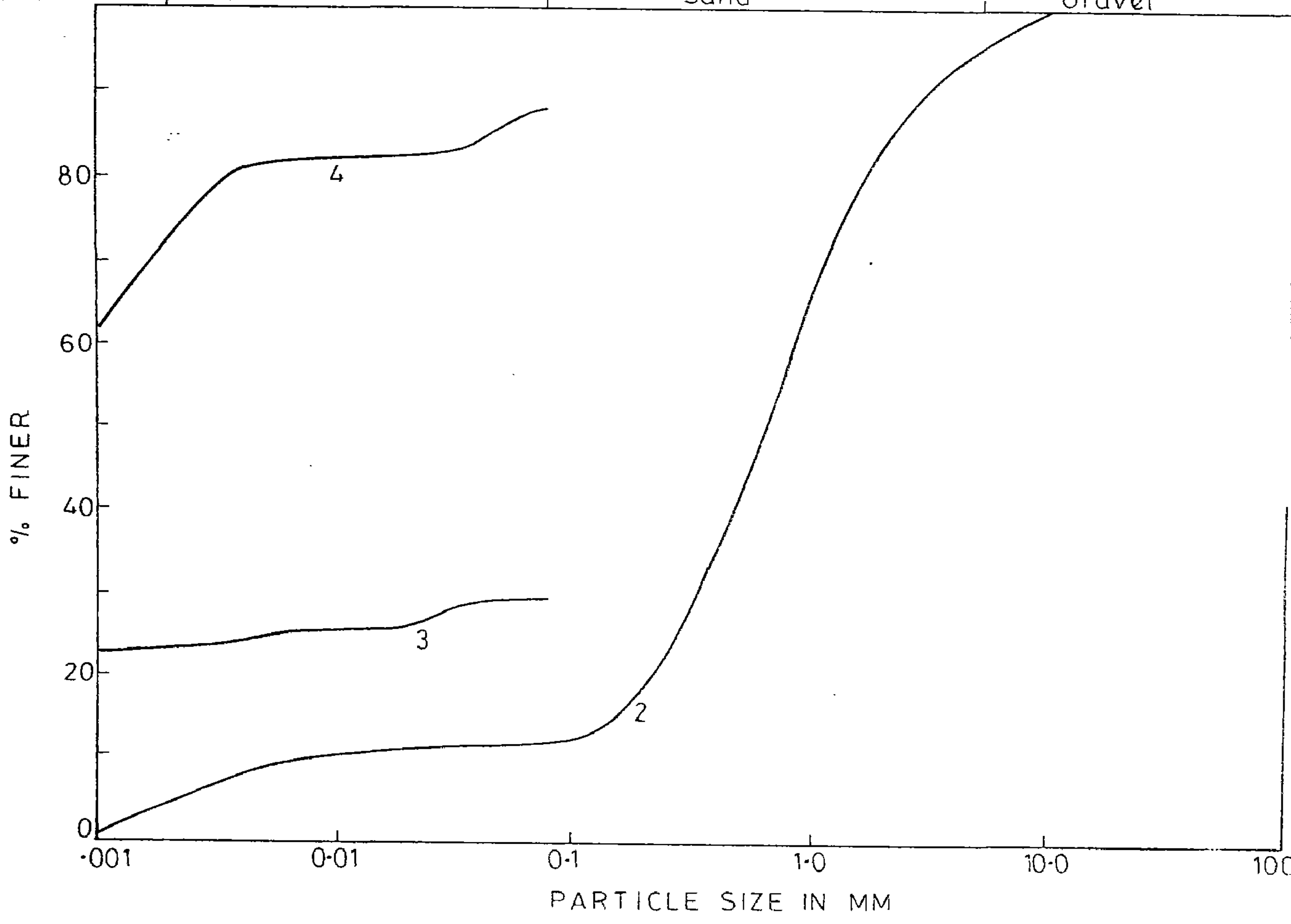


FIG. 4·4 X-RAY DIFFRACTION PATTERN OF CUTTING SAMPLE NO.-4



Sand
Gravel
80
60
40
20
0
% FINER
4
3
2
·001
0·01
0·1
1·0
10·0
100
PARTICLE SIZE IN MM

4.3 Seasonal variation :

As the principal objective of this work was to look for local factors controlling chloride concentration in well waters, it was thought necessary to monitor the selected wells over the annual cycle before and after the monsoon period. The depth to water table and selected chemical parameters like pH, conductivity (Total dissolved solids), chloride and sodium were measured in the month of June and September 1985. The results are presented in Table No. 4.2 and 4.3.

Table No. 4.2 : Partial analysis of well water in June, 1985

Well No.	Water level depth in meters	pH	Conductivity u mhos/cm	T.D.S.* in PPM	Chloride in PPM	Sodium in PPM
1	4.35	7.5-8	260	169	48.49	15.5
2	10.32	8	1360	884	405.63	135
3	1.95	7-7.5	240	156	39.16	12.75
4	24.0	9.7	1530	994.5	88.6	281.25
5	5.25	7	220	143	41.03	9.5
6	9.15	7.5	550	357.5	82.99	21.25
7	21.6	6.5-7	1490	968.5	480.24	70
8	2.1	6.5	150	97.5	42.9	7.5

NB : *Total dissolved solids were calculated from conductivity using the factor 0.65

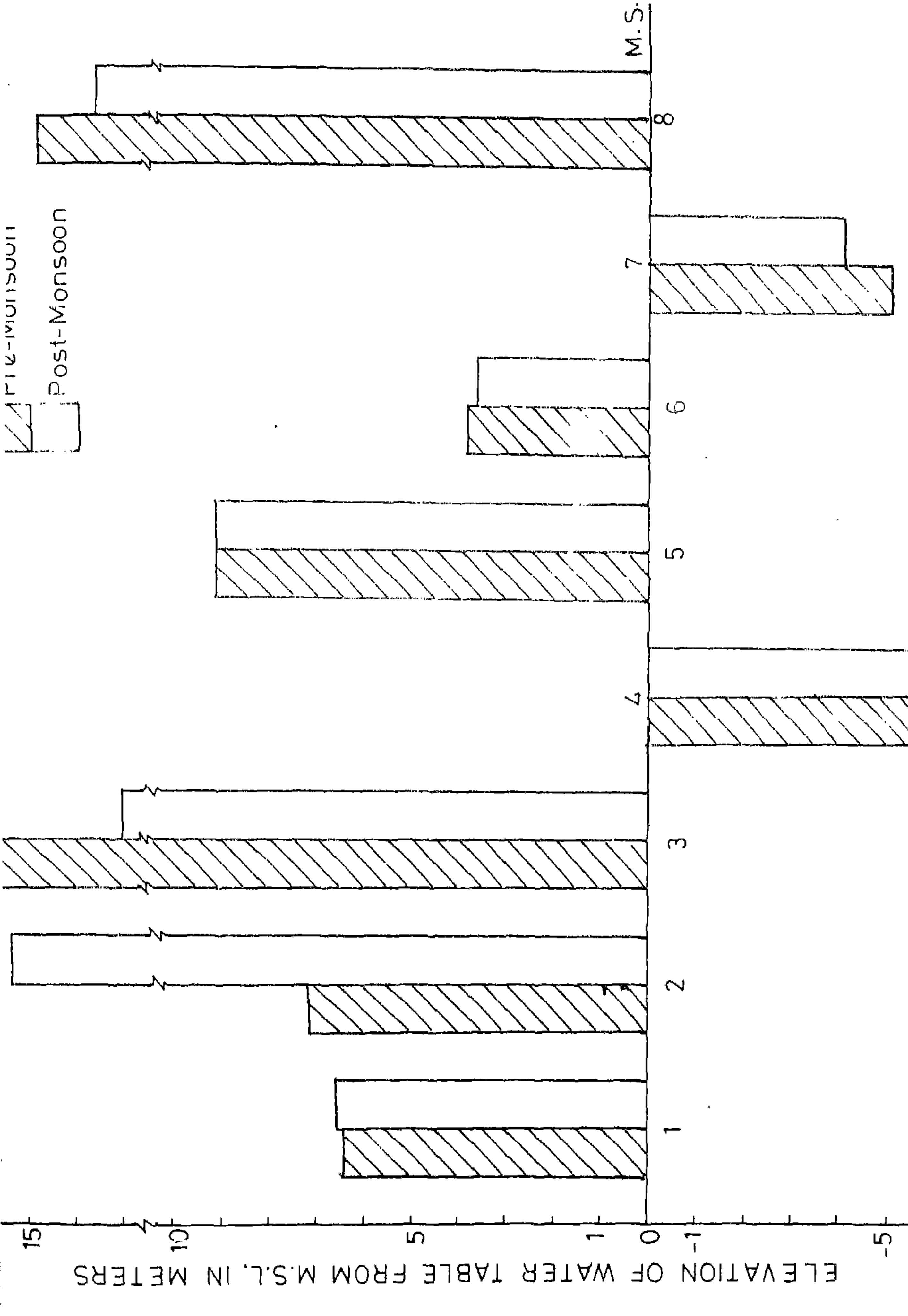
$$TDS = 0.65 \times \text{conductivity} \ (\mu \text{ Mhos/cm})$$

Table No. 4.3 : Partial analysis of well water in September, 1985

Well No.	Water level depth in meters	pH	Conductivity u mhos/cm	T.D.S.* in ppm	Chloride in ppm	Sodium in ppm
1	4.2	7	270	175.5	35.44	11.50
2	2.1	7.5-8	1210	886.5	279.8	70
3	4.5	6.5-7	200	130	37.3	10.50
4	24	7	270	175.5	74.62	18.75
5	5.25	6.5	230	149.5	46.63	8.75
6	9.3	7-7.5	700	461.5	146.0	40
7	20.7	6.5	1600	1040	503.65	80
8	3.3	6.5	120	78	18.65	6.5

The depth to water level data have been recalculated to height above Mean Sea level (M.S.L.) from reduced levels, and plotted as bar graphs in Fig. 4.6. It is clear that there is no systematic variation from premonsoon to post monsoon seasons. The effect on most wells is negligible. Only well No. 2 shows a distinct rise in water level after the monsoon. On the other hand, there is no definite explanation for the slight fall in level in Well No. 3, 6 and 8.

The pattern of variation of Na^+, Cl^- and TDS is same for each well. For most wells there is a negligible difference from


ELEVATION OF WATER TABLE FROM M.S.L. IN METERS
15
10
5
1
0
-1
-5
M.S.
1
2
3
4
5
6
7
8
Pre-Monsoon
Post-Monsoon

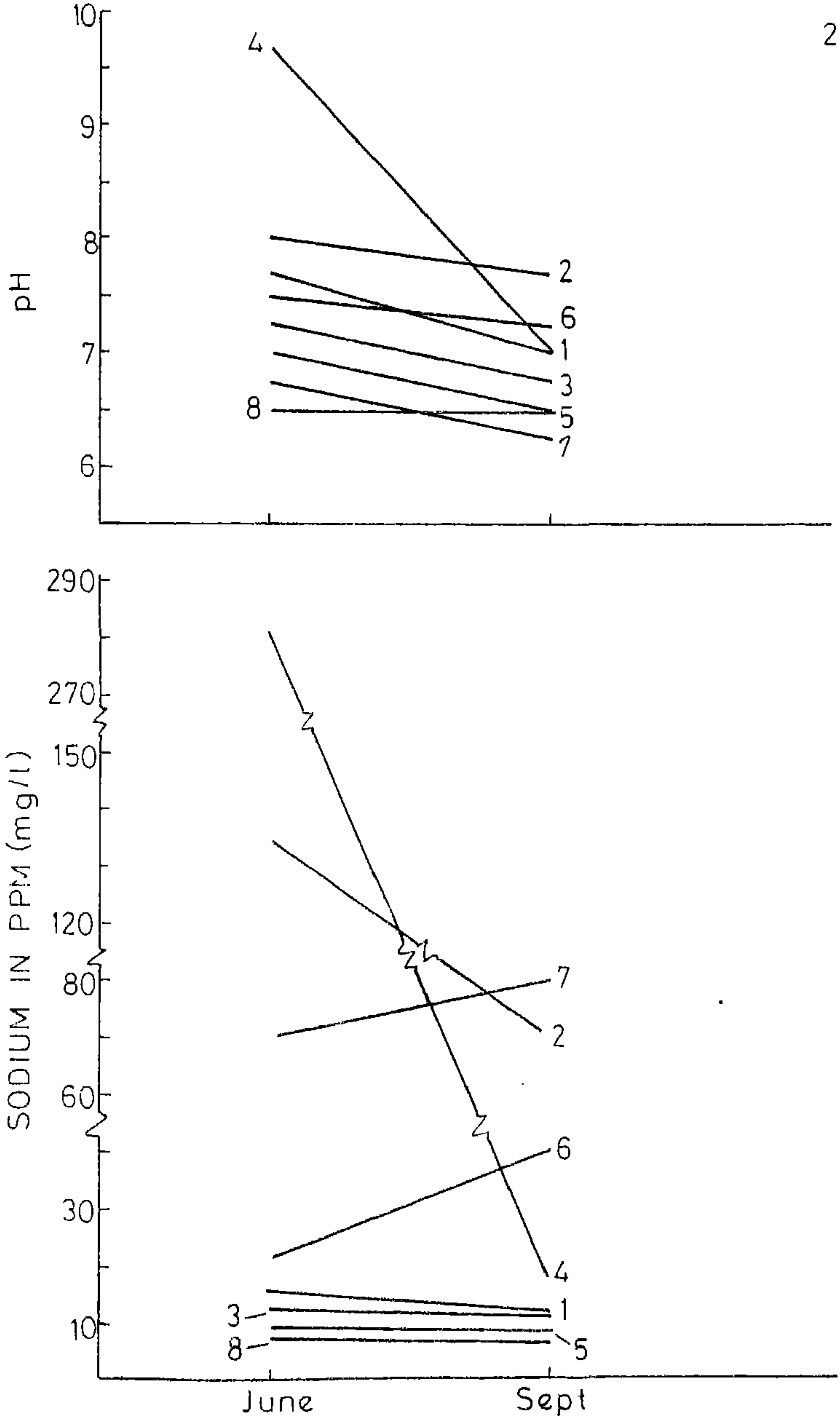
June to September (Fig. 4.7, 4.8 and 4.9). Well No. 2 on the other hand, shows a distinct lowering of Na^+, Cl^- and TDS after the monsoon, accompanied by a rise in water level. Therefore, this effect can be explained by dilution.

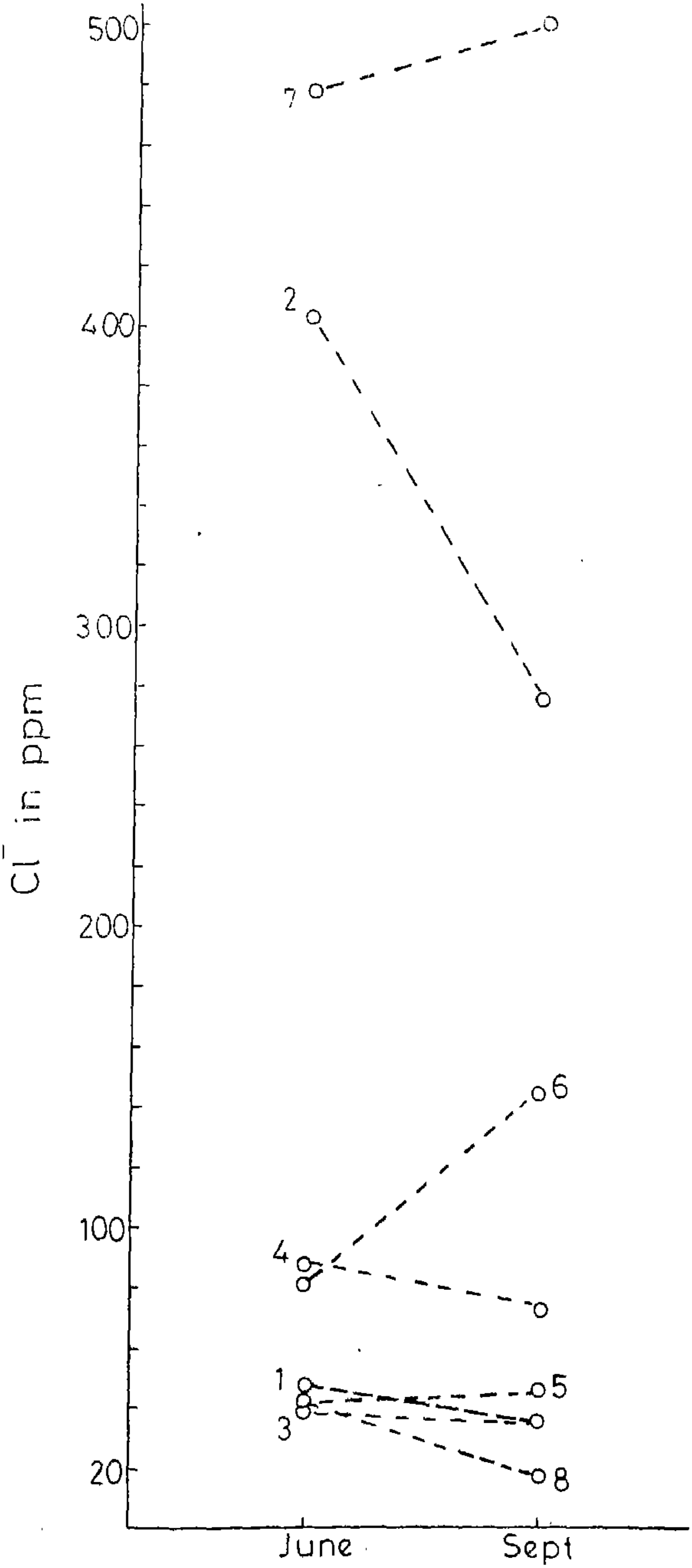
In Well No. 7, concentration of Na^+, Cl^- and TDS have increased after monsoon inspite of a rise in water level. In Well No. 6 the concentrations have increased after monsoon along with a slight lowering in water level. As both the wells are situated near salt pans and populated areas, dissolved salt and domestic sewage carried by flood water may have surpassed the effect of change in water level.

4.4 Factors Influencing Chloride in a Given Season :

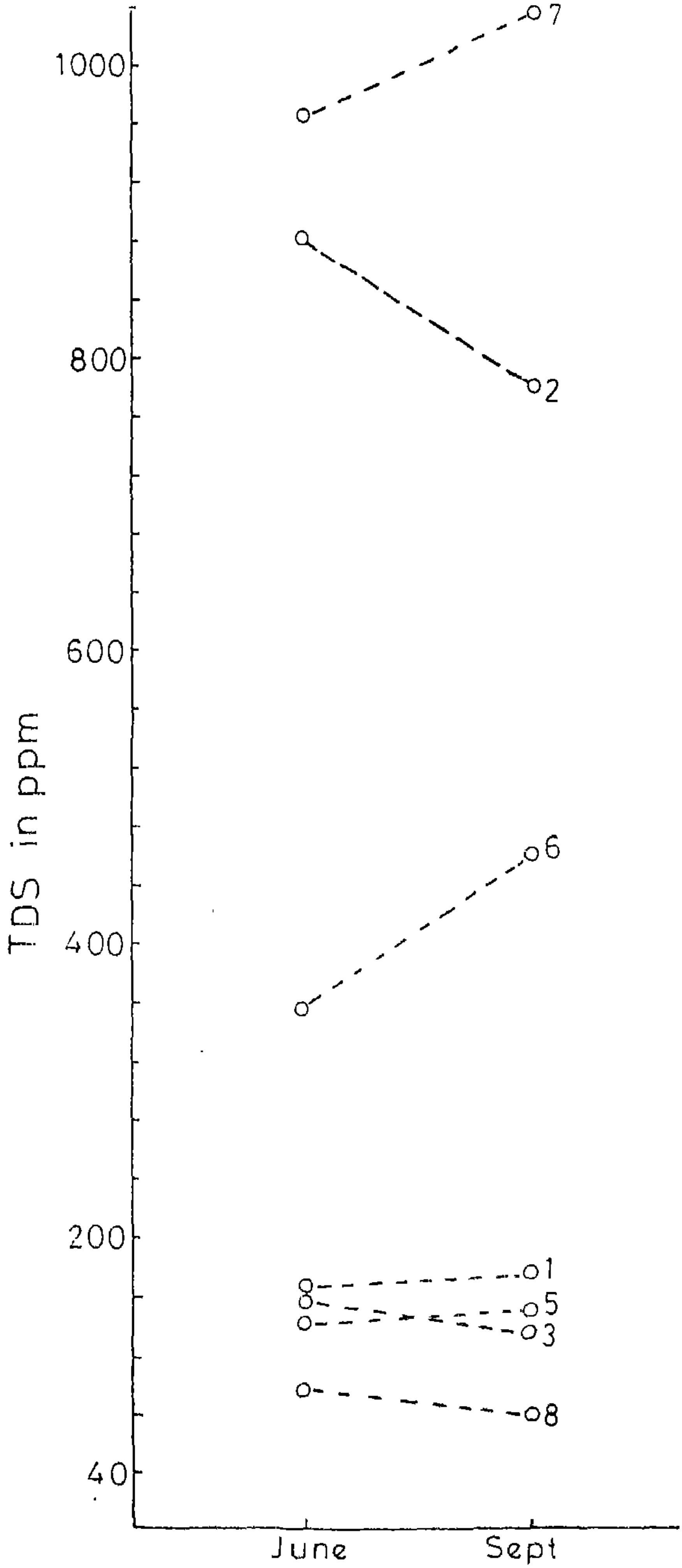
As seen from the analysis presented in Table No. 4.2 and 4.3, all the waters except No. 8 in post monsoon period have chloride value higher than 20 ppm. According to the criterion of Tremblay et al. (1973), they represent the mixture of seawater and fresh water. However, the seawater fraction is obviously low because the highest chloride content is 503 ppm. The same fact was established by measuring the specific gravity of the water (weight of known volume of each sample). It was not possible to detect any difference in specific gravity from the fresh water value equal to 1.0. Thus these waters are extremely diluted versions of seawater.

Chloride will enter ground water systems mainly as NaCl.


pH
10
9
8
7
6
4
8
2
6
1
3
5
7
SODIUM IN PPM (mg/l)
290
270
150
120
80
60
30
10
7
2
6
4
3
1
8
5
June
Sept



FIG·4·8 SEASONAL VARIATION IN CHLORIDE


TDS in ppm
1000
800
600
400
200
40
June
Sept
7
2
6
1
5
3
8

Therefore, it is reasonable to expect that chloride concentration will be related to Na^+. At the same time, chloride will be the major dissolved constituent in mixed water of coastal aquifers, therefore, it will virtually control the total dissolved solid contents. In other words, waterswith high chloride are also expected to have high T.D.S. Lastly, the marginal increase in density due to salinity will control the occurrence of high chloride water at greater depth. Therefore, in the present study 3 major parameters have been investigated as controlling factors for chloride namely (1) Sodium content, (2) T.D.S. and (3) Depth. These are discussed separately in the following paragraphs.

4.4.1 : Sodium versus Chloride

Among the various constituents in ground water, chloride is considered to be a conservative component because it does not take part in any rock-water reaction except dissolution of salt beds. The variation in chloride is therefore possible only through mixing, evaporation or dilution. On the other hand, chloride is introduced into water mainly as NaCl. Therefore, the relationship $Na^+ = Cl^-$ on an equivalent basis is a useful reference line.

The ppm values of Na^+ and Cl^- from tables 4.2 and 4.3 have been converted into meq/l using the conversion formula meq/l = ppm(mg/l)xvalency(=1)/Atomic Weight and recorded in tables No. 4.4 and 4.5 for pre and post monsoon seasons. The data have been plotted in Fig. 4.10 and 4.11 for the two seasons. The world average sea water composition with Na = 10,500 mg/l and Cl^- =

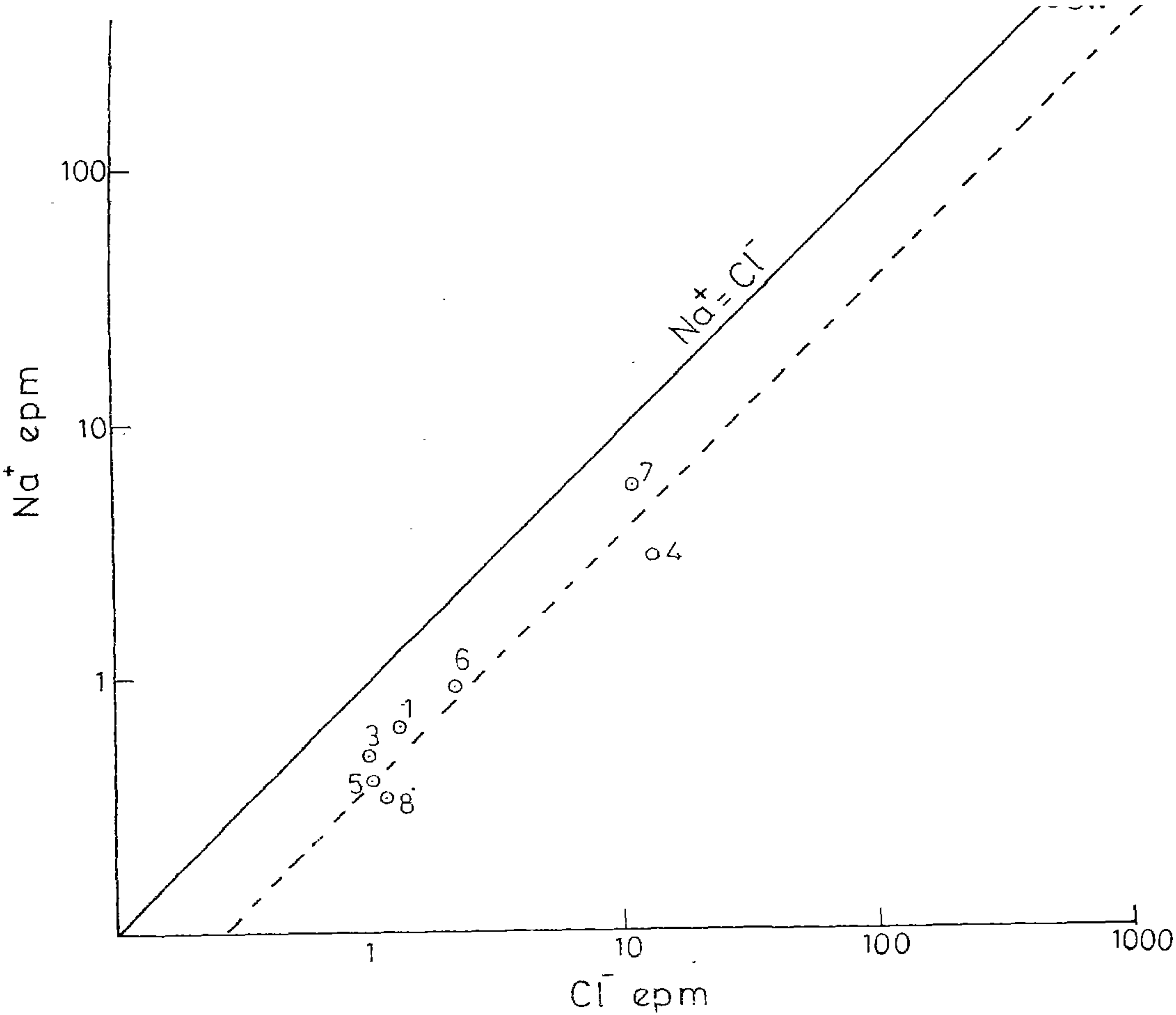


FIG. 4.10 EVOLUTION OF Na^+ AND Cl^- IN WELL WATER BY DILUTION

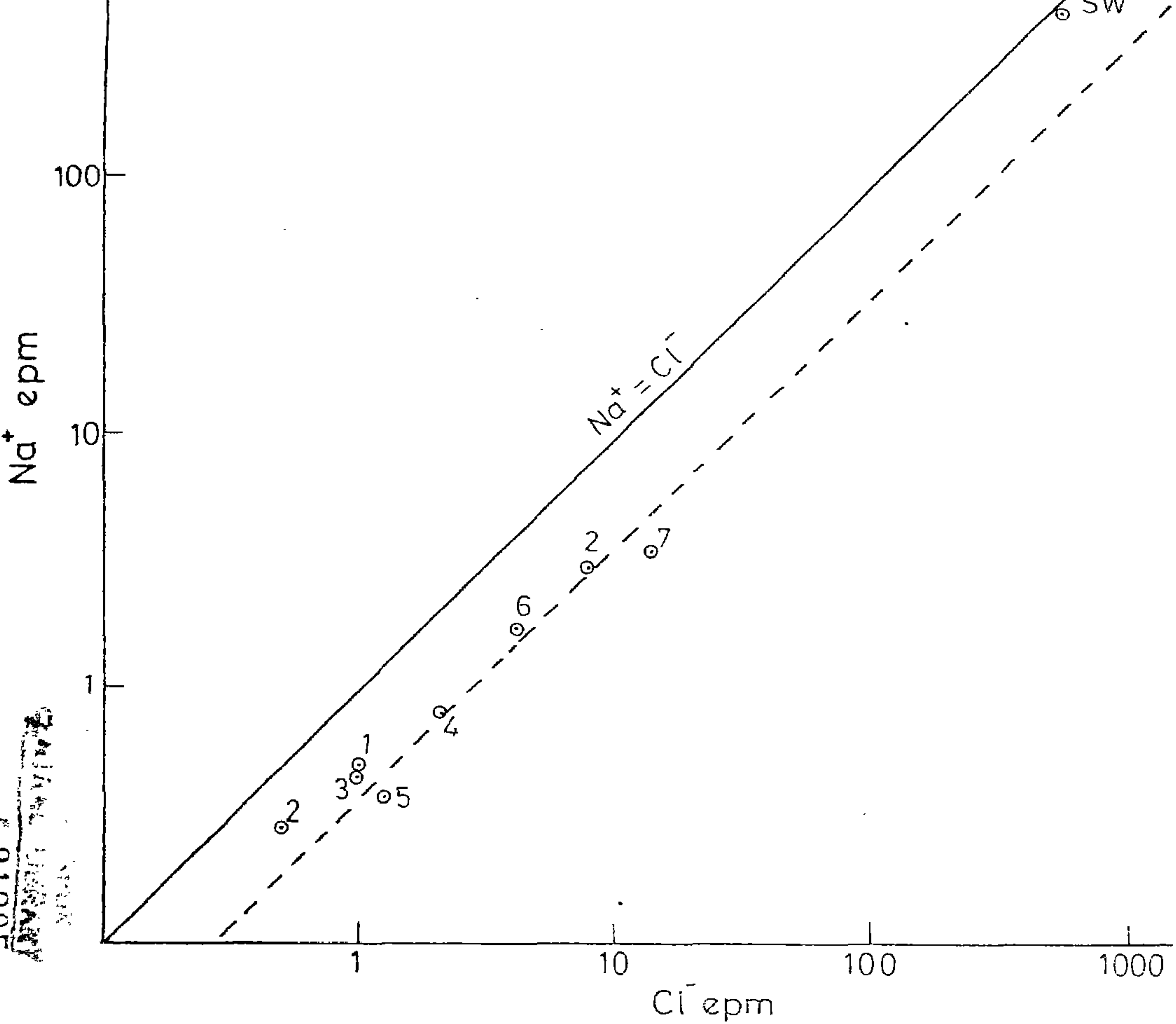


FIG. 4.11 EVOLUTION OF Na$^+$ AND Cl$^-$ IN WELL WATER BY DILUTION

19000 mg/l. (Mackenzie and Garrels, 1966) is also plotted in the same diagrams.

Table No. 4.4 , meq/l (epm) values of sodium and chloride in pre monsoon period

Well No.	Chloride	Sodium
1	1.367	0.6739
2	11.4423	5.869
3	1.1046	0.554
4	2.499	12.228
5	1.157	0.413
6	2.341	0.923
7	13.5468	3.043
8	1.210	0.326
SW	525.29	447.79

SW : World average sea water (from Mackenzie and Garrels, 1966)

Table No. 4.5 : meq/l (epm) values of sodium and chloride in Post monsoon period

Well No.	Chloride	Sodium
1	.999	.500
2	7.8916	3.043
3	1.052	0.4565
4	2.104	0.8152
5	1.315	0.380
6	4.117	1.739
7	14.205	3.478
8	.526	0.2826

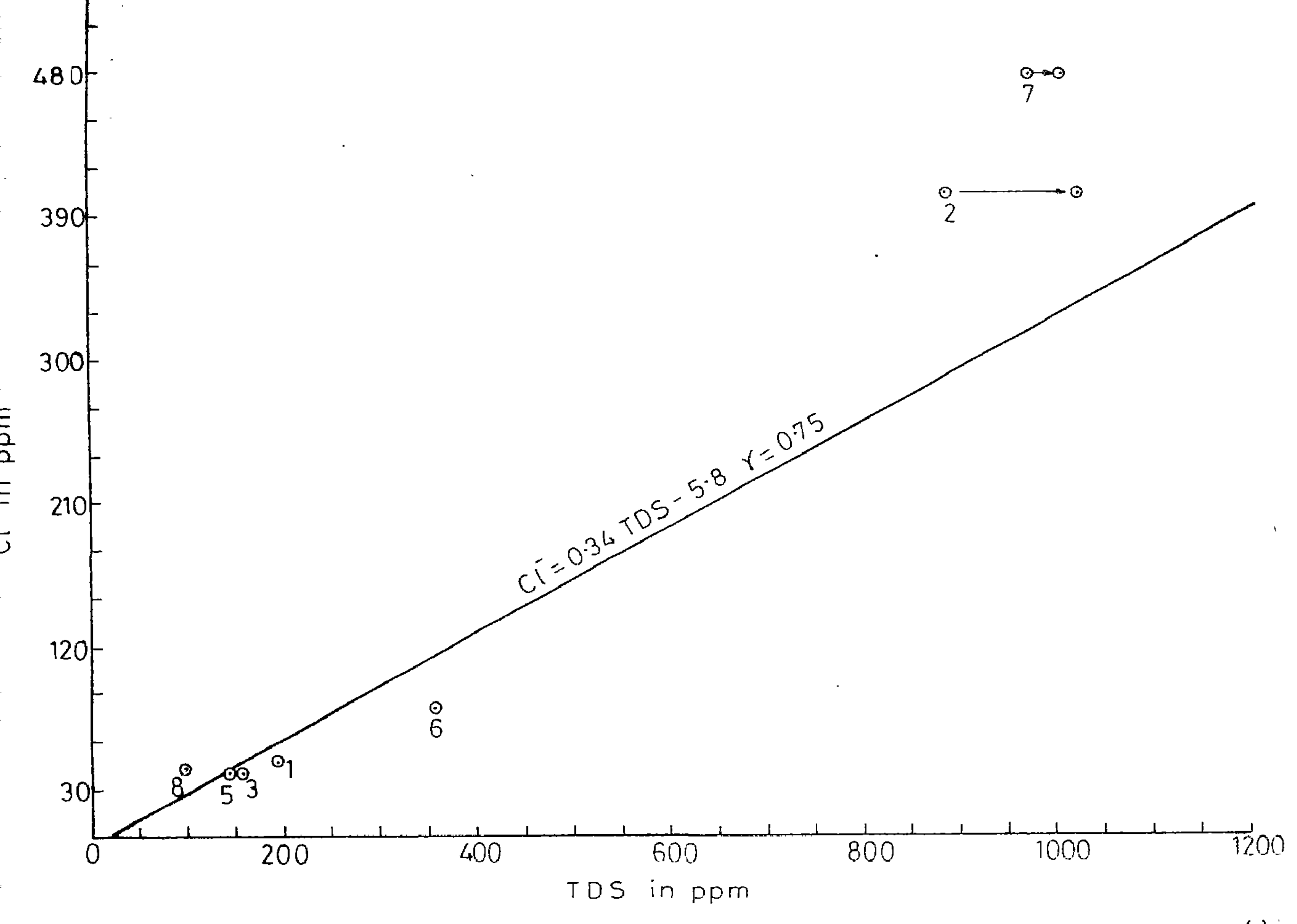
Both diagrams show that the well waters are greatly diluted sea water in pre- and post monsoon seasons. There is a linear relation of Na^+ with Cl^- but in all waters chloride is slightly greater than Na^+ on an equivalent basis. This is possibly because (1) Chloride is balanced by other cations like, K^+, Ca^{++} and (2) Ion exchange reaction with aquifer materials may have resulted in loss of Na^+ ion.

4.4.2 : Variation of chloride with TDS

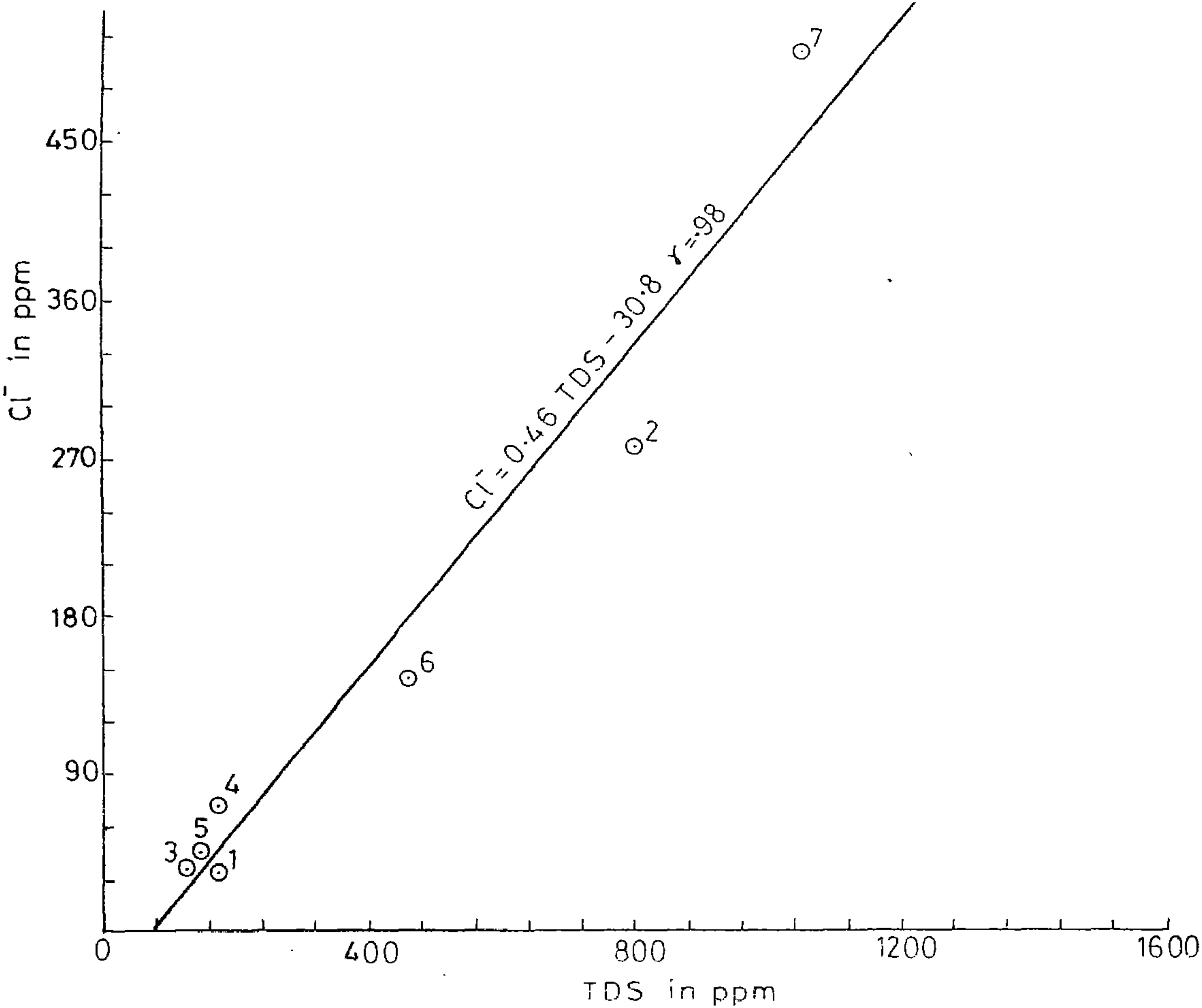
The expected parallel increase of chloride and TDS was verified from the data presented in tables 4.2 and 4.3. It is to be noted that most of the TDS values are calculated from measurement of conductivity and using the empirical relationship TDS(mg/l)= 0.65 x conductivity (μ mhos/cm).

The same values have plotted in Fig. 4.12 and 4.13 for pre and post monsoon periods. The equations for the regression line plotted through the Cl^- and TDS values are (1) Cl^- = 0.34 TDS - 5.8 with correlation coefficient = 0.75 for pre monsoon and (2) Cl^- = 0.46 TDS - 30.82 with correlation coefficient = 0.98 for post monsoon period.

It is seen that there is a deviation from the straight line relationship at higher TDS values (> 400 mg/l). This may be due to two reasons, (1) The empirical factor 0.65 between TDS and conductivity may not be valid at high TDS values, (2) Presence of non-ionic species at high TDS will result in an



Cl⁻ in ppm
480
390
300
210
120
30
0
200
400
600
800
1000
1200
TDS in ppm
Cl⁻ = 0·34 TDS - 5·8 Y = 0·75
1
2
3
5
6
7
8



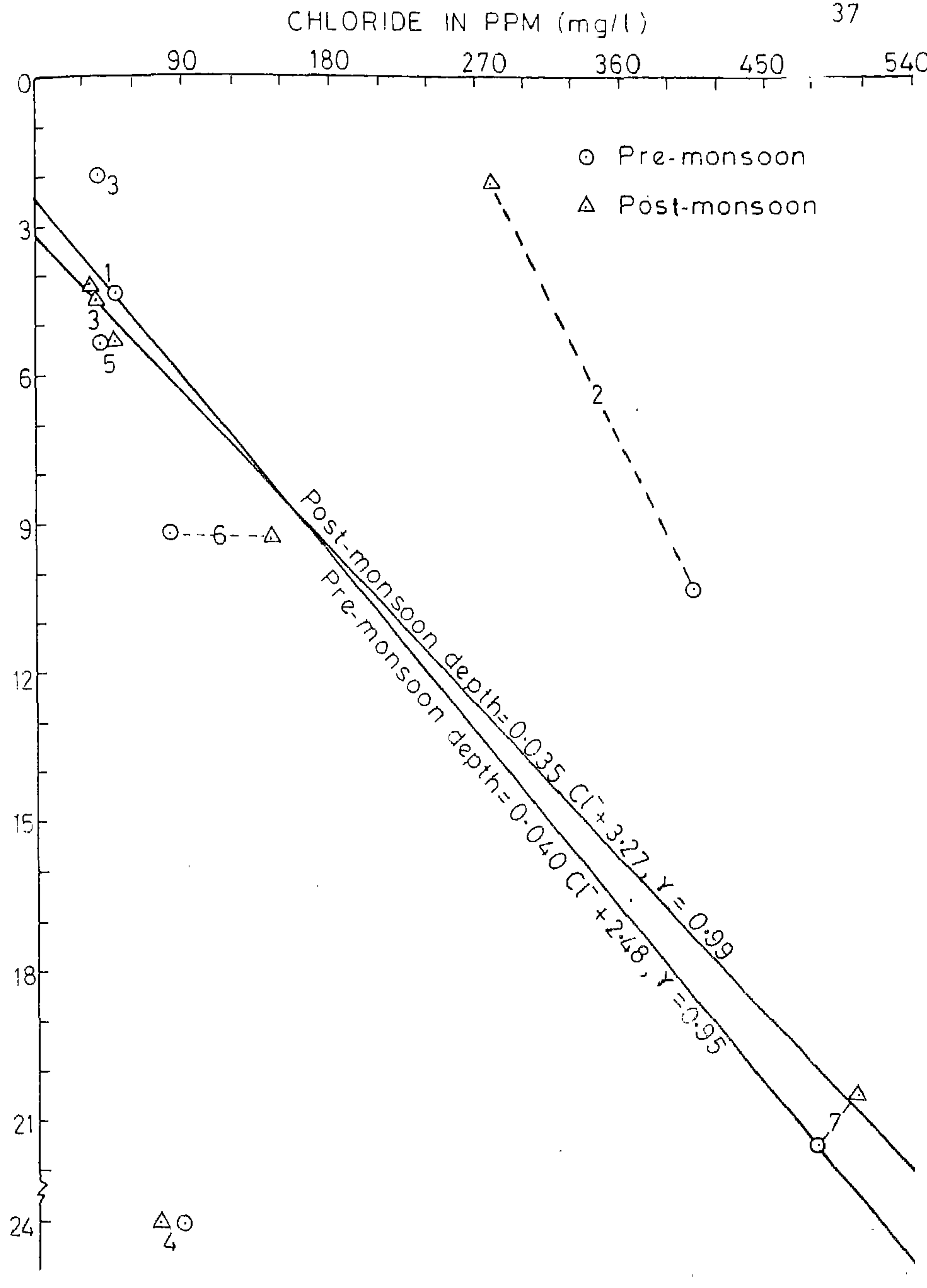
Cl⁻ in ppm
450
360
270
180
90
0
400
800
1200
1600
TDS in ppm
Cl⁻ = 0·46 TDS - 30·8 γ = ·98
1
2
3
4
5
6
7

under estimate of TDS from conductivity measurement. The second possibility was verified by determination of TDS for samples . 2 and 7 in the pre-monsoon period by evaporation method. As expected, the points shift towards the regression line after this modification (Fig. 4.12). It is, therefore, confirmed that high TDS waters have high chloride content in coastal aquifers as observed by Tremblay et al.(1973) in the Summerside area. However, TDS is linearly related to chloride mostly at low values.

4.4.3 Variation of chloride with depth :

In coastal aquifers, the equilibrium between fresh water and salt water is usually given by the Ghyben-Hergberg relationship which states that the ratio of height of fresh water table to depth to salt water interface is approximately 1:40. This is based on the density difference between fresh water and salt water. As a result, deep wells in coastal regions have high chloride salt water. However, in the present area of investigation in the Kanyakumari Coast, none of the wells has penetrated the seawater zone. The very dilute salt water found in these wells indicate that they are in the diffusion zone, much above the fresh water-sea water interface before and after monsoon.

Fig. No. 4.14 shows the relationship between depth to water table from ground surface and chloride content in each well . If we leave out the plots for well no. 2 and 4, the remaining 6



FIG·4·14 VARIATION OF CHLORIDE WITH DEPTH

wells show a linear relationship with regression equations (1) Depth = 0.04 Cl + 2.48 for premonsoon period with correlation coefficient of 0.95, (2) Depth = 0.03 Cl + 3.27 for post monsoon period with correlation coefficient of 0.99.

It is clear from this figure that well No. 2 shows relatively high chloride at shallow depth whereas in Well No. 4, chloride content is relatively low eventhough the water level remains below M.S.L. before and after the monsoon. It is obvious that some local factors have influenced the depth versus chloride relationship in these two wells.

Fig. 4.15 and 4.16 have been constructed to show variation of ground elevation and height of water with respect to M.S.L. for each well. It can be seen that well No. 2 is situated close to a stream channel open to the sea (Refer Fig. no. 3.1). Moreover, study of the aquifer material of this well, discussed earlier, indicates that the well is located in a highly permeable sandy soil. This, according to the personal communication from Tamil Nadu Water and Drainage Board, represents the top soil over weathered sandstone. It is, therefore, likely that seawater entering the stream channel infiltrates into this well through the permeable soil cover and locally raises the chloride content.

These two figures also show that the depth to water in Well No. 4 is similar to a depression of a normal water table passing between Well No. 3 and 5. This is due to large scale

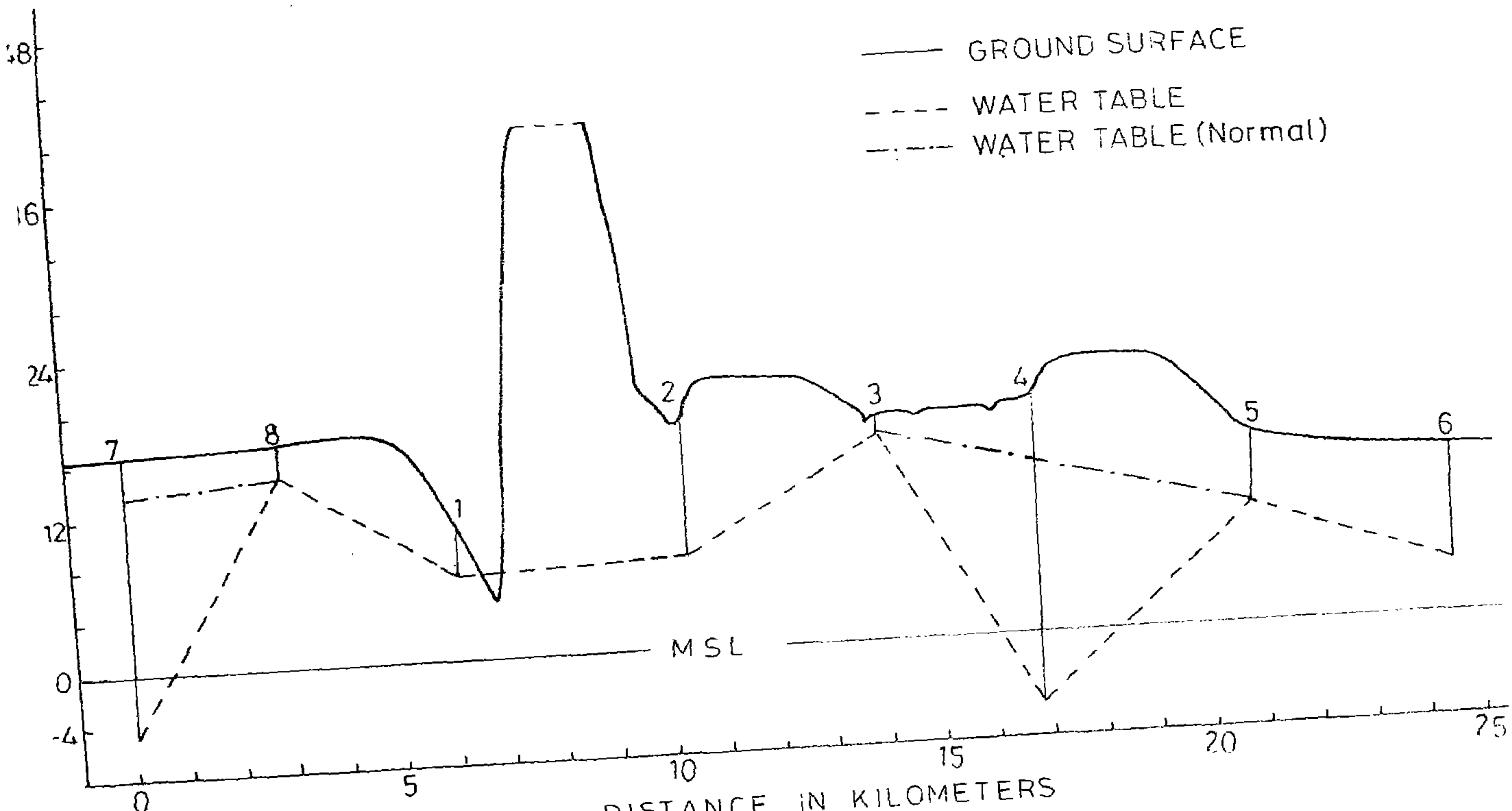


FIG. 4.15 VARIATION OF GROUND ELEVATION AND HEIGHT OF WATER WITH RESPECT TO M.S.L. FOR PREMONSOON SEASON

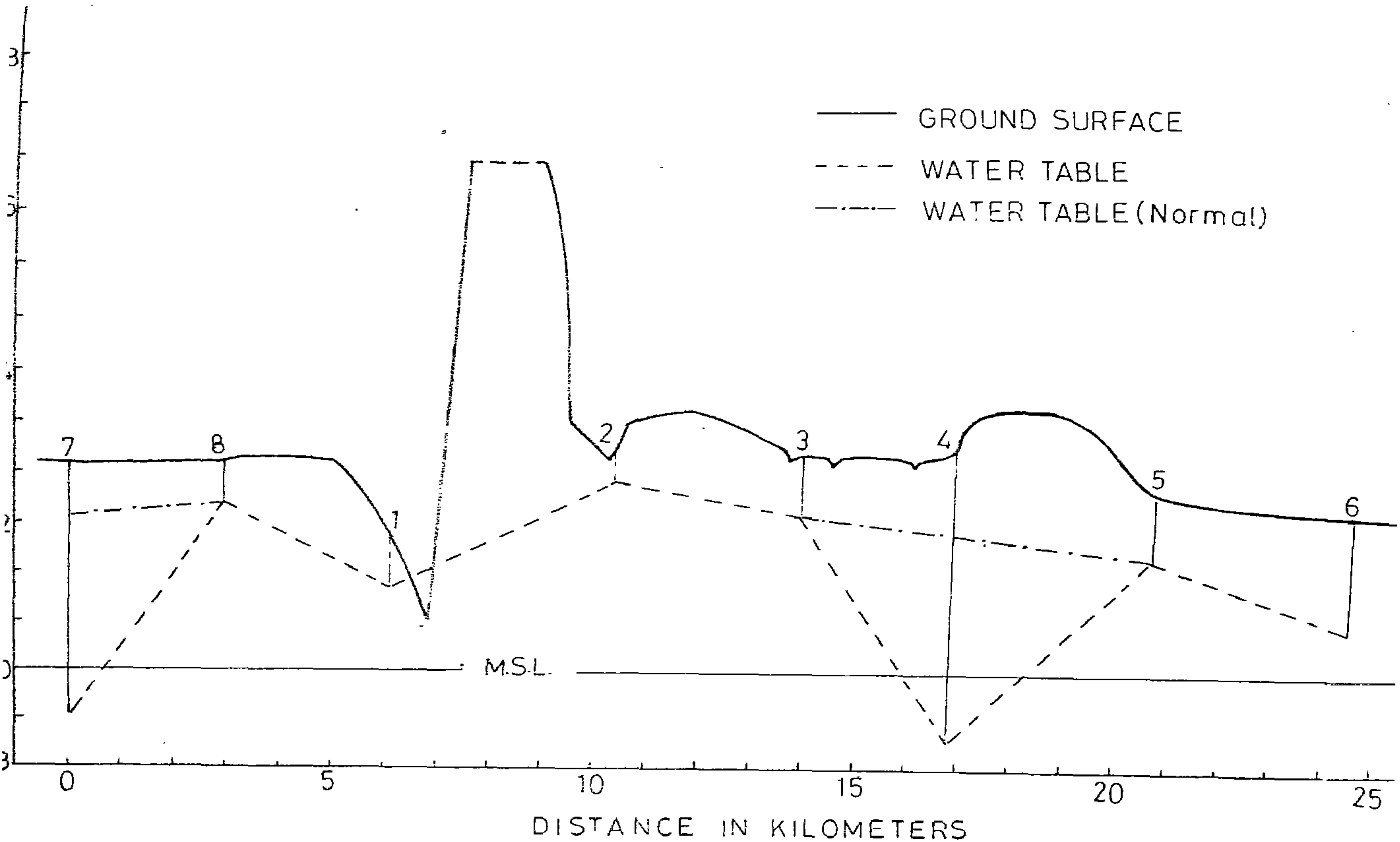


FIG. 4.16 VARIATION OF GROUND ELEVATION AND HEIGHT OF WATER WITH RESPECT TO M.S.L. FOR POST MONSOON SEASON

pumping in wells located in the extensive cultivated lands in this region. Study of the aquifer material from this well has indicated high clay content suggesting low permeability. It is possible, therefore, that the depth to water table in well No. 4 represents a non-equilibrium value caused by failure to recover to the actual shallow depth through the impermeable clay beds. Therefore, the relatively low chloride content probably represents a value corresponding to a much shallower depth.

The geometry of the water table in well No. 7 also suggests a temporary lowering due to overpumping. Although no detailed information on the aquifer is available, the reports on the local geology indicate that this well goes through clay beds of the Warkalli formations. On the other hand, the chloride content of this well is the highest because of its nearness to a salt pan and a town as discussed earlier.

In order to represent the regional variation of chloride along this coast, isochlor maps and sections for the month of June and September 1985 have been constructed in Fig. 4.17, 4.18, 4.19 and 4.20. It is clear from the maps that there are chloride maxima near Well No. 7 and 2. The sections show that the maximum in Well No. 2 is influenced by the topography i.e. its location near a stream channel open to the sea. The sections also show that the isochlor values generally increase with depth. Well No. 8,1, 3 and 5 are in the zone above the 50 ppm isochlor line

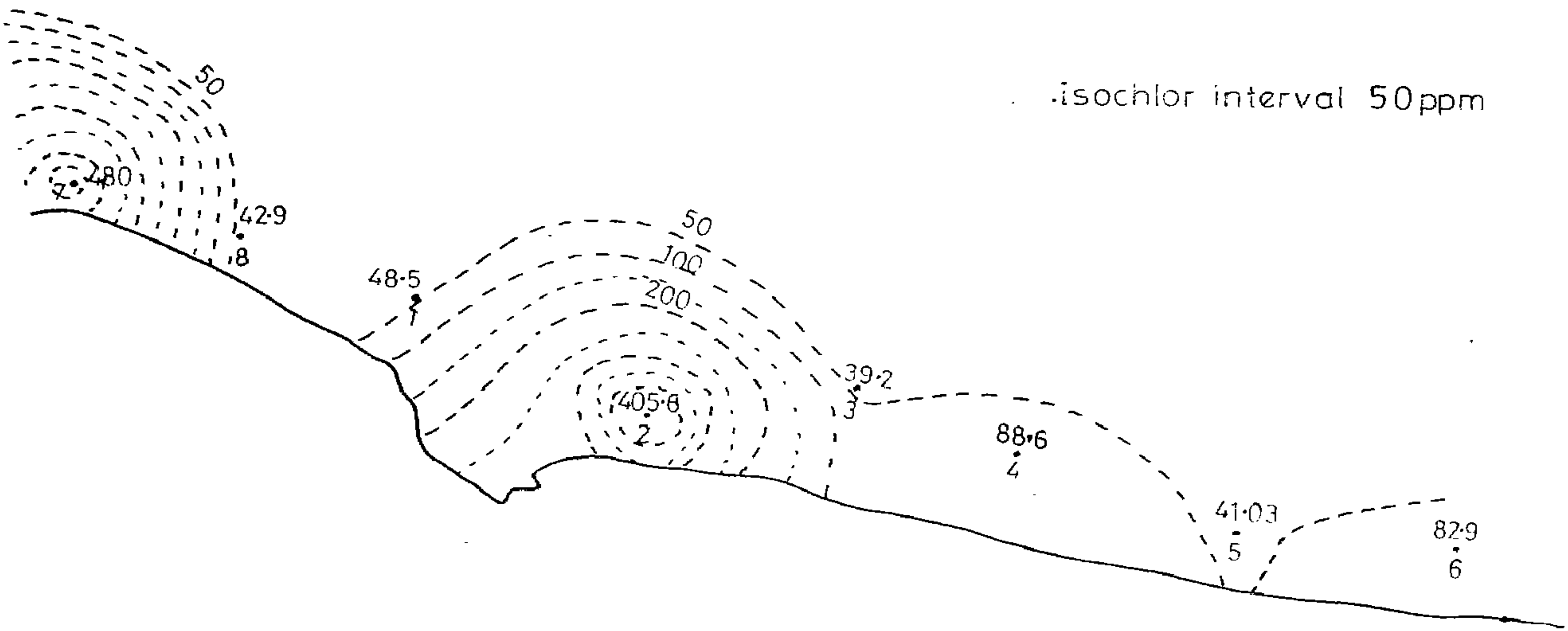


Fig. 4·17 Isochlor map for the month of June 1985 in a part of Kanyakumari coastal area

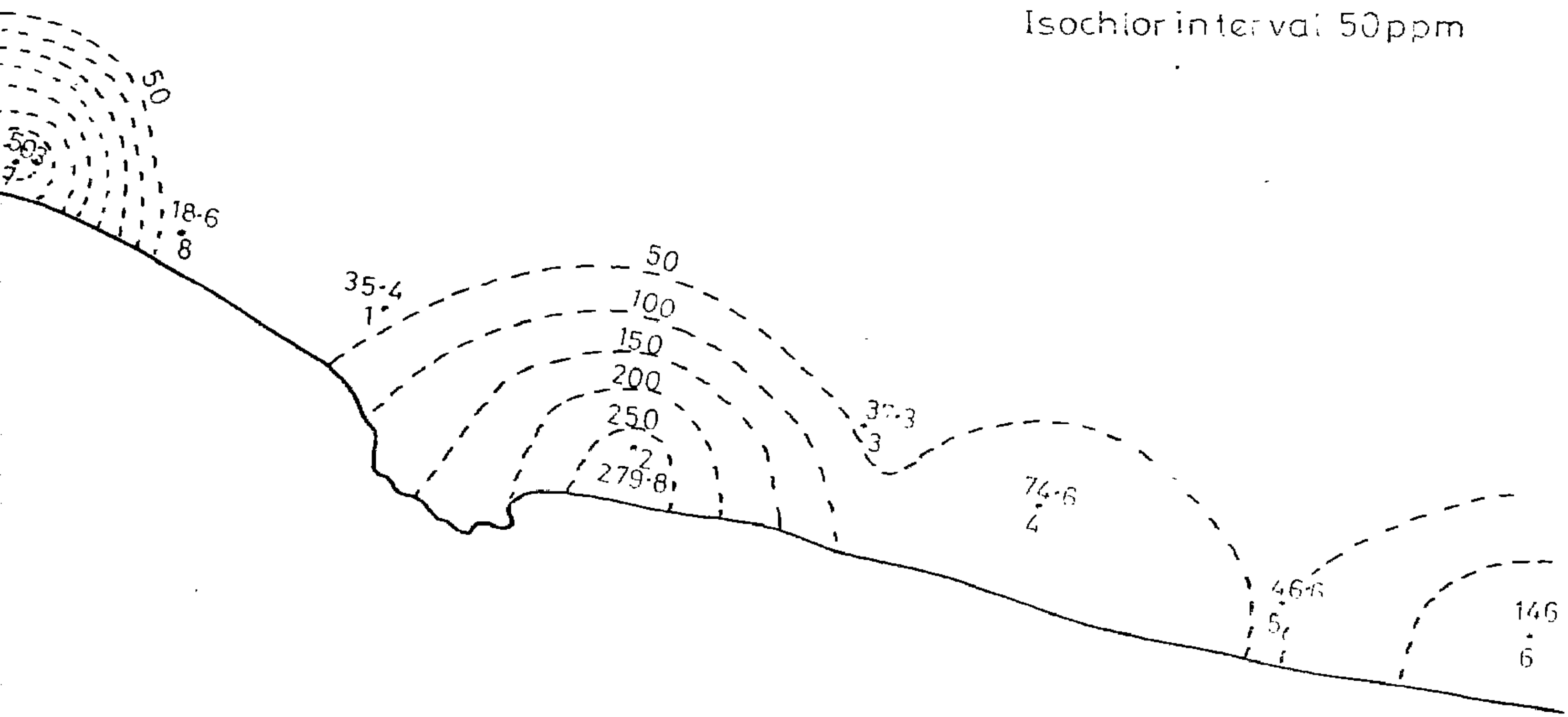


Fig.4·18 Isochlor map for the month of September 1985 in a part of Kanyakumari coastal area

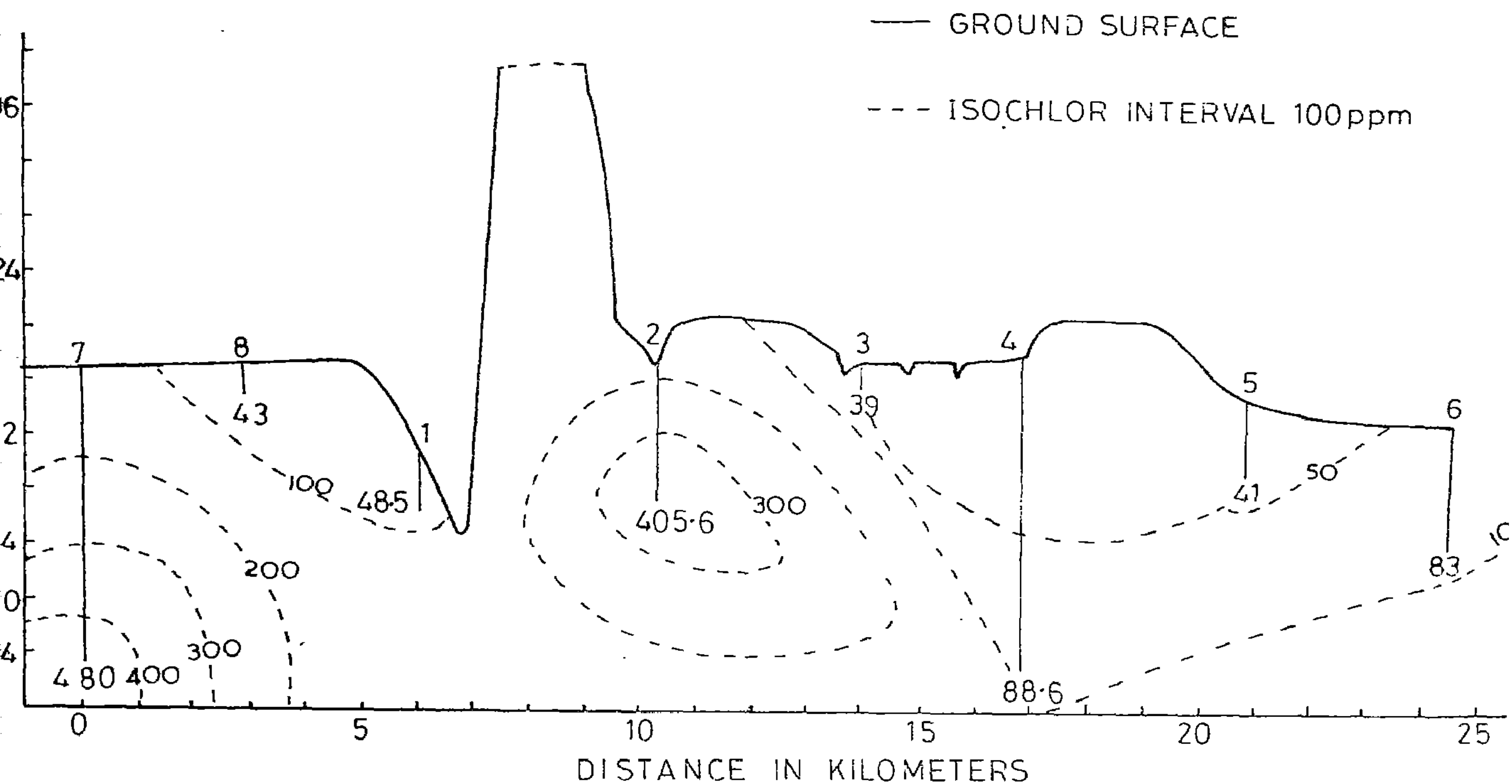


FIG. 4.19 ISOCHLOR SECTION FOR THE MONTH OF JUNE 1985 IN A PART OF KANYAKUMARI COASTAL AREA

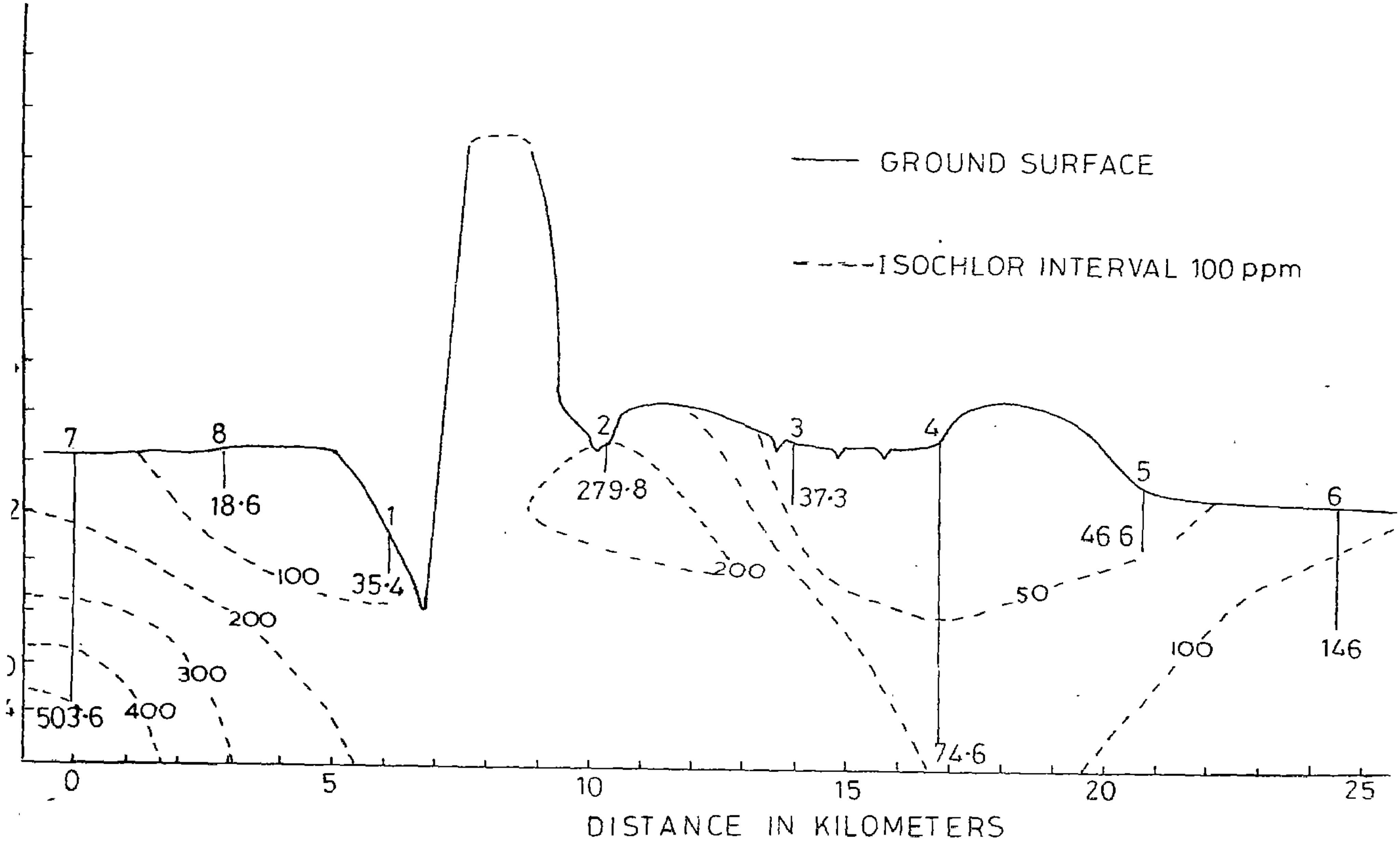


FIG.4.20 ISOCHLOR SECTION FOR THE MONTH OF SEPTEMBER 1985 IN A PART OF KANYAKUMARI COASTAL AREA

before and after monsoon. Well No. 4 and 6 are in the zone above 100 ppm isochlor in the pre monsoon period. However, the 100 ppm isochlor moves above the level of Well No. 6 after the monsoon.

CHAPTER-5

CONCLUSIONS

Eight open wells near the coast of Kanyakumari district were selected for monitoring chloride levels. Geologically, the wells are located in coastal sands. However, the lithology is highly variable with local clay zones. The wells are relatively shallow and the water is used for domestic supply and irrigation. It is not surprising, therefore, that the chloride content is relatively low. The following features indicate that the variation of chloride concentration in shallow open wells is influenced more by local factors than by a regional intrusion of sea water.

(1) Cl only slightly exceeds Na on an equivalent basis and their variation is linear parallel to the Na=Cl line. This suggests that Cl is introduced mainly as NaCl. Comparison with the average sea water value indicates there has been considerable dilution by mixing with fresh water.

(2) The data on Well No. 2 indicate that sea water moving into a tidal stream channel infiltrates to shallow depths through a highly permeable sandy soil.

(3) In the same well there is a significant rise in water level after the monsoon with lowering in Na, Cl and TDS values.

(4) Although high Cl waters also have high TDS, their variation is not linear above TDS = 400 mg/l.

(5) Nearness to salt pans and villages locally raises Cl values as in well No. 6 and 7.

(6) Although Cl values generally increase with depth, occu-rrence of clay rich soils near well No. 4 causes a depression of low-Cl water due to over-pumping.

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